

ANNUAL REPORT FOR 2003



Little Sugar Creek Mitigation Site

Mecklenburg County

Project No. 8.U670122

TIP No. R-211 DA



Office of Natural Environment & Roadside Environmental Unit
North Carolina Department of Transportation
December 2003

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SUMMARY

The Little Sugar Creek Mitigation Site, located in Mecklenburg County, is in its seventh year of monitoring. Approximately 21 acres in size, the site was to serve as mitigation for the R-211DA section of the Charlotte Outer Loop. It was constructed in the winter of 1996-97. The site must demonstrate hydrologic and vegetation success for a minimum of three years or until the site is deemed successful.

The daily rainfall data depicted on the gauge data graphs was recorded from an onsite rain gauge that was installed on May 4, 2000. Additional Charlotte rainfall data used for the 30-70 graph was provided by the NC State Climate Office. The onsite rain gauge experienced periodic malfunctions; therefore rainfall data from the Charlotte weather station was used for the gauge graphs. In 2003, Charlotte experienced a wet growing season, resulting in an average to above average rainfall year.

In August 2003, NCDOT provided a letter to the U.S. Department of the Army to address the hydrologic concerns of securing an additional 13.1 acres of wetlands to replace the Little Sugar Creek Mitigation Site (Appendix D). NCDOT is currently in discussion regarding this issue.

In October 2003, The Catena Group, Inc. conducted a site visit to evaluate the Little Sugar Creek Mitigation Site. The investigation examined soil features to determine any correlation between the past and current conditions on the site. The report can be found in Appendix E. Mitigation Site Soil Analysis.

During the 2003-monitoring year, six of the nine gauges met the jurisdictional hydrology (saturation for 12.5% of the growing season). Two of the nine gauges that did not meet success experienced malfunctions, early in the growing season. The surface water gauges indicated persistent surface water in the channels throughout the growing season.

The emergency spillway modifications improved the site, hydraulically in the 2003-monitoring year. During an average to above average rainfall year, eight of the nine-groundwater gauges improved from the 2002-monitoring year (below average rainfall year).

Vegetation survival rates at the site are above the minimum success criteria. The average density for bottomland hardwood species was 408 trees per acre after seven years. Planted shrub species were observed at a density of 317 stems per acre. NCDOT proposes to discontinue vegetation monitoring at the Little Sugar Creek Mitigation Site.

NCDOT will continue to monitor the site for hydrology.

1.0 INTRODUCTION

1.1 PROJECT DESCRIPTION

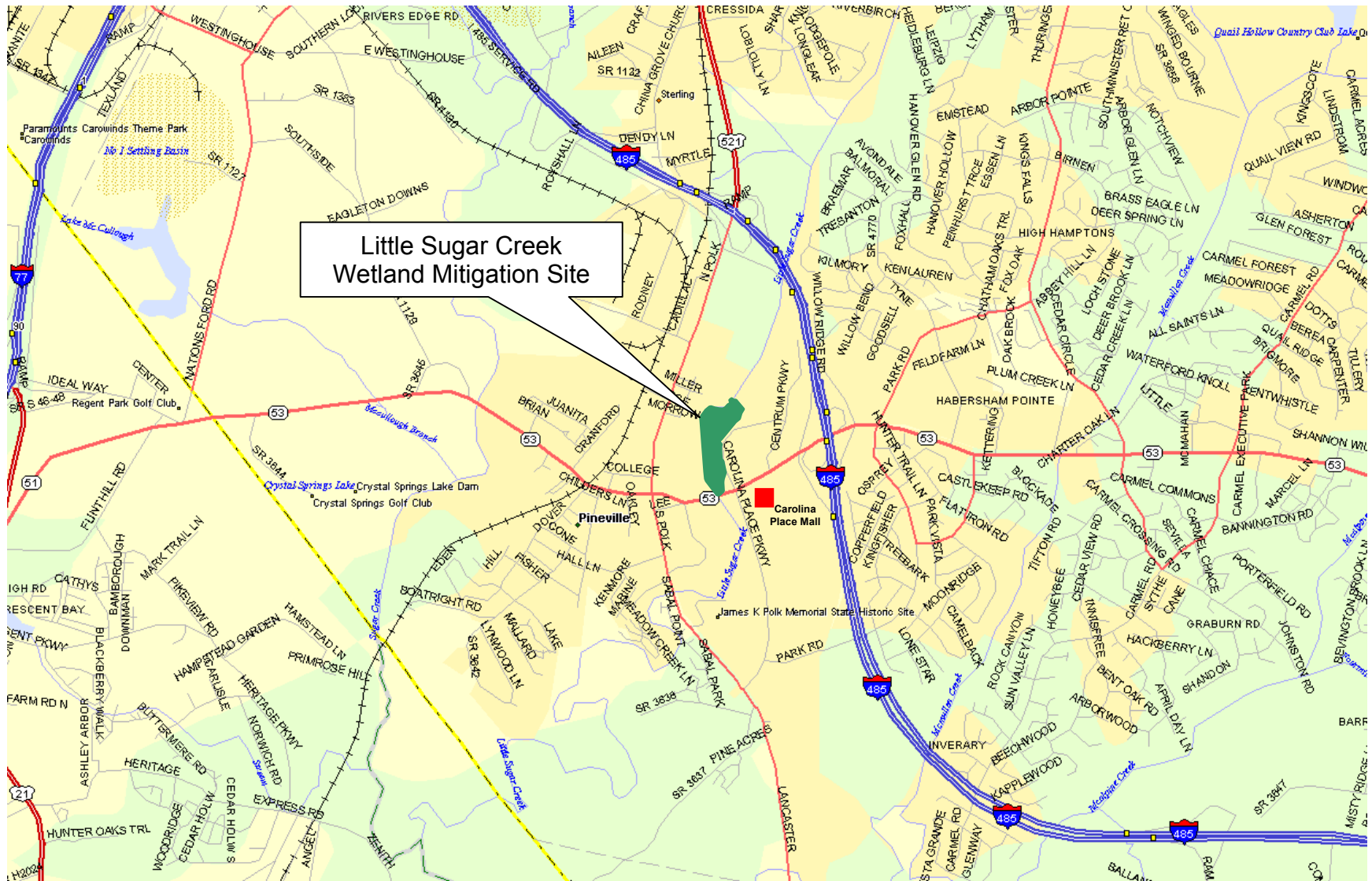
The Little Sugar Creek Mitigation Site is located in Mecklenburg County. The site, which encompasses approximately 21 acres, is situated at the intersection of Highway 51 and Leitner Drive (Figure 1). It was designed as mitigation for a portion of the Charlotte Outer Loop project that extends from NC 51 to Rea Road (TIP No. R-211 DA, USACE Action ID 199200013).

The project provides for the restoration/creation of bottomland forest, shrub-scrub wetland, and emergent marsh. The site was originally constructed in the winter 1996-97; NCDOT performed supplemental planting work in 1998. The site is in its second year of hydrologic and vegetation monitoring following the site modification prior to the 2002 growing season.

1.2 PURPOSE

In order to demonstrate successful mitigation, Little Sugar Creek is monitored for both hydrology and vegetation. The following report describes the results of the hydrologic and vegetative monitoring during 2003 at the Little Sugar Creek Mitigation Site. Included in this report are the hydrologic and vegetation monitoring results, as well as an analysis of local climate conditions throughout the growing season, and site photographs.

Figure 1. Site Location Map



1.3 PROJECT HISTORY

March 1997	Site Planted
March-November 1997	Hydrologic Monitoring (1 yr.)
September 1997	Vegetation Monitoring (1 yr.)
March 1998	Shrub Area Replanted
March-November 1998	Hydrologic Monitoring (2 yr.)
September 1998	Vegetation Monitoring (2 yr.)
March-November 1999	Hydrologic Monitoring (3 yr.)
September 1999	Vegetation Monitoring (3 yr.)
March-November 2000	Hydrologic Monitoring (4 yr.)
September 2000	Vegetation Monitoring (4 yr.)
February 2001	Raised Weir at Sheet Piles
March-November 2001	Hydrologic Monitoring (5 yr.)
June 2001	Vegetation Monitoring (5 yr.)
March 2002	Adjusted Emergency Spillway Elevations
March-November 2002	Hydrologic Monitoring (6 yr.)
August 2002	Vegetation Monitoring (6 yr.)
March-November 2003	Hydrologic Monitoring (7 yr.)
September 2003	Vegetation Monitoring (7 yr.)
October 2003	Soils Investigation

1.4 DEBIT LEDGER

Table 1. Little Sugar Creek Mitigation Site Debit Ledger

Site Habitat	Mitigation Plan			TIP Debit
	Wetland Acres At Start	Acres Remaining	% Remaining	R-211DA
BLH, Scrub Shrub, FWM	16.1	0	0.0	16.1

BLH: Bottomland Hardwood FWM: Freshwater Marsh

2.0 HYDROLOGY

2.1 SUCCESS CRITERIA

In accordance with federal guidelines for wetland mitigation, the success criteria for hydrology state that areas must be inundated or saturated (within 12 inches of the surface) by surface or groundwater for at least a consecutive 12.5% of the growing season. Areas inundated for less than 5% of the growing season are always classified as non-wetlands. Areas inundated between 5% and 12.5% of the growing season can be classified as wetlands depending upon such factors as the presence of wetland vegetation and hydric soils.

The growing season in Mecklenburg County begins March 22 and ends November 11 (235 days). These dates correspond to a 50% probability that air temperatures will not drop below 28°F or lower after March 22 and before November 11.¹ Minimum wetland hydrology is required for at least 12.5% of this growing season; for Mecklenburg County, this 12.5% equals 29 consecutive days. Local climate must represent average conditions for the area in order for the hydrologic data to be considered successful.

2.2 HYDROLOGIC DESCRIPTION

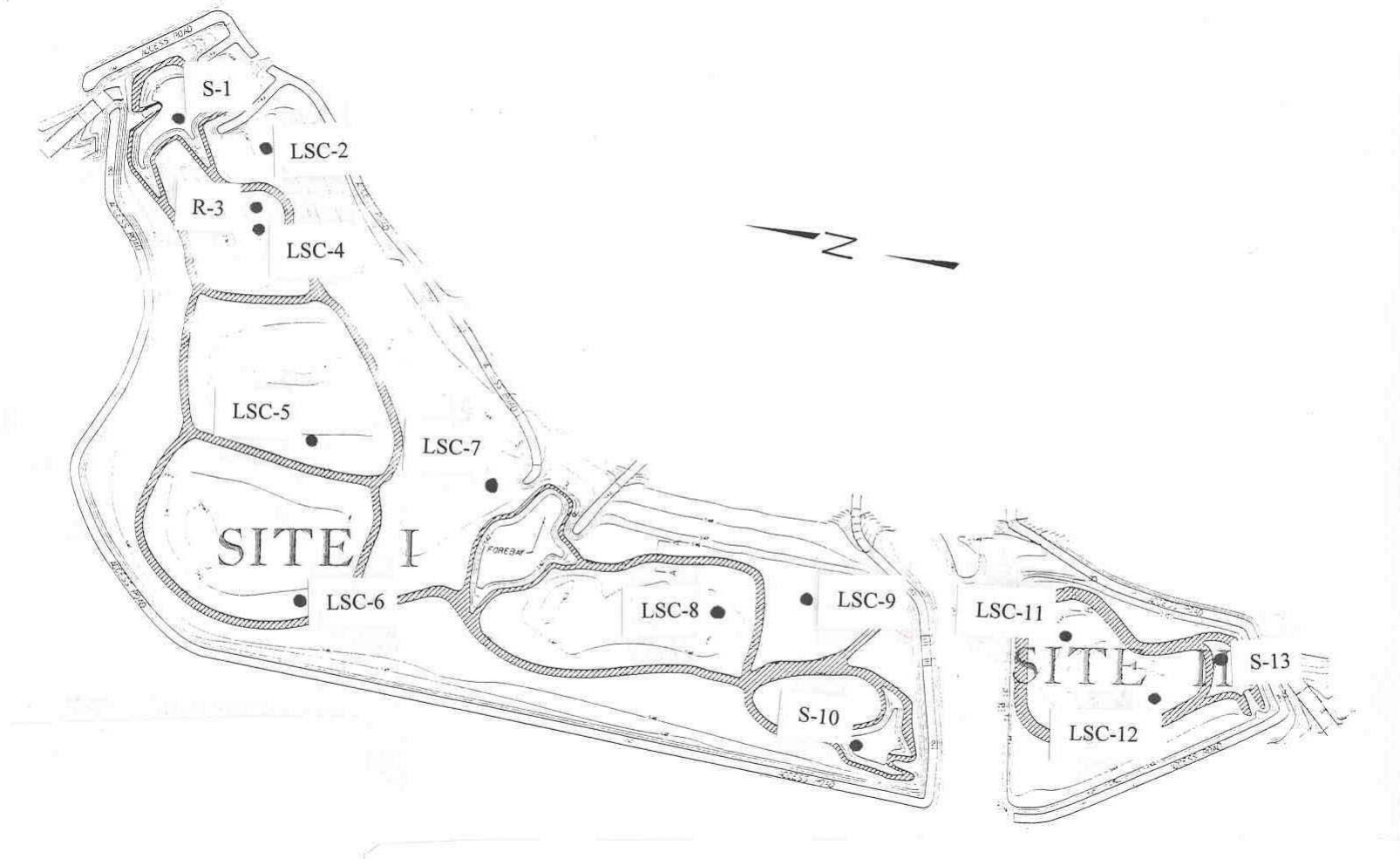
Nine groundwater gauges, one rain gauge, and three 80-inch surface water gauges were installed in 1997 (Figure 2). The automatic monitoring gauges record daily readings of the groundwater depth.

The sluice gates, which were closed in July 1999 to hold surface water on the site, remained closed in 2003. In an attempt to further augment the site hydrology, the weir was raised approximately eight inches in the ditch where the sheet piles are located and clay was added to the face of the rip-rap at the emergency spillway in 2001. The elevation of both emergency spillway outlets was raised to match the elevation of the flood control structure in March 2002.

Runoff from the surrounding area is the primary hydrologic input to the Little Sugar Creek Site. A stormwater pipe, running underneath Leitner Drive, releases water collected from adjacent shopping centers near Gauge 9. The monitoring gauges on the site show the effects of the stormwater collected in the channels, as well as the effects of specific rainfall events on the groundwater table.

¹ Natural Resources Conservation Service, Soil Survey of Mecklenburg County, North Carolina, p.61.

Figure 2. Gauge Location and Site Modification Map



2.3 RESULTS OF HYDROLOGIC MONITORING

2.3.1 Site Data

To determine if the site met the federal guidelines (saturation within 12 inches of the surface for at least 12.5% of the growing season), the maximum number of consecutive days that the groundwater was within twelve inches of the surface was determined for each gauge. This number was converted into a percentage of the 235-day growing season. The results are presented in Table 2.

Appendix A contains a plot of the groundwater and surface water depth for each groundwater and surface gauge, respectively. The individual precipitation events, shown on the monitoring gauge graphs as bars, represent data collected from the on-site rain gauge or from a Charlotte weather station (provided by the NC State Climate Office). The maximum number of consecutive days is noted on each graph. The rain gauge on the site was replaced with a more accurate measuring device prior to the 2000-monitoring season.

The placement of the groundwater gauges and a graphical representation of the hydrologic monitoring results are provided in Figure 3.

Table 2. 2003 Hydrologic Monitoring Results

Monitoring Gauge	< 5%	5-8%	8-12.5%	> 12.5%	Actual %	Dates of Success
LSC-2				✕	39.6	April 17-July 18 July 30-Aug 28
LSC-4	✕				0.9	
LSC-5			✕		10.6	Aug 4-Aug 28
LSC-6				✕	41.7	March 22-June 27
LSC-7				✕	40.9	March 22-June 25
LSC-8				✕	14.0	July 30-August 31
LSC-9				✕	19.1	June 7-July 21 July 30-August 30
LSC-11		✕			7.7	
LSC-12				✕	17.0	March 22-April 30

The 2003 growing season experienced an above average rainfall year.

Specific gauge problems:

- Gauge 4 did not record data from January to July 17 or August 26 to November 13 due to battery failure and gauge replacement.
- Gauges 2, 5, 8, 9 were not downloaded during the beginning of the growing season due to the depth of inundation around the gauges.
- Gauge 5 had a battery failure June 7 to July 17.

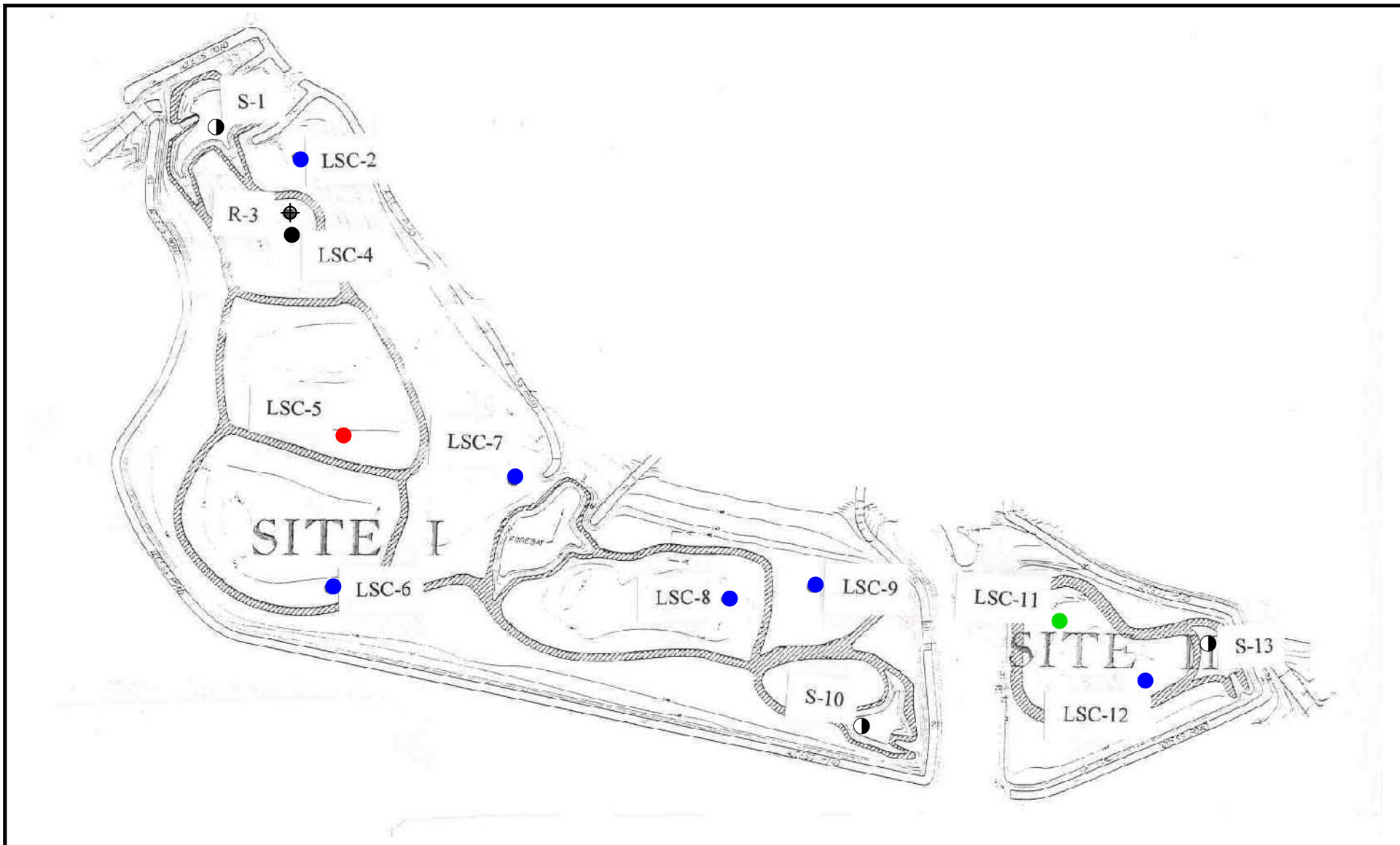


Figure 3. 2003 Hydrologic Monitoring Gauge Results

Hydrology Results

- < 5%
- 5 - 8%
- 8 - 12.5%
- > 12.5%

- ⊕ Rain Gauge
- Surface Gauge



Not to Scale



2.3.2 Climatic Data

Figure 4 is a comparison of 2002 and 2003 monthly rainfall to historical precipitation for the area. This comparison indicates if 2003 was “average” in terms of climate conditions by comparing the rainfall to that of historical rainfall (data collected between 1972 and 2003). The NC State Climate Office provided all historical data.

For the 2003-year, November (02'), December (02'), March, April, May, June, July, and August experienced above average rainfall. The months of January, October, and November recorded below average rainfall for the site. February and September experienced average rainfall. Overall, 2003 experienced an average to above average rainfall year.

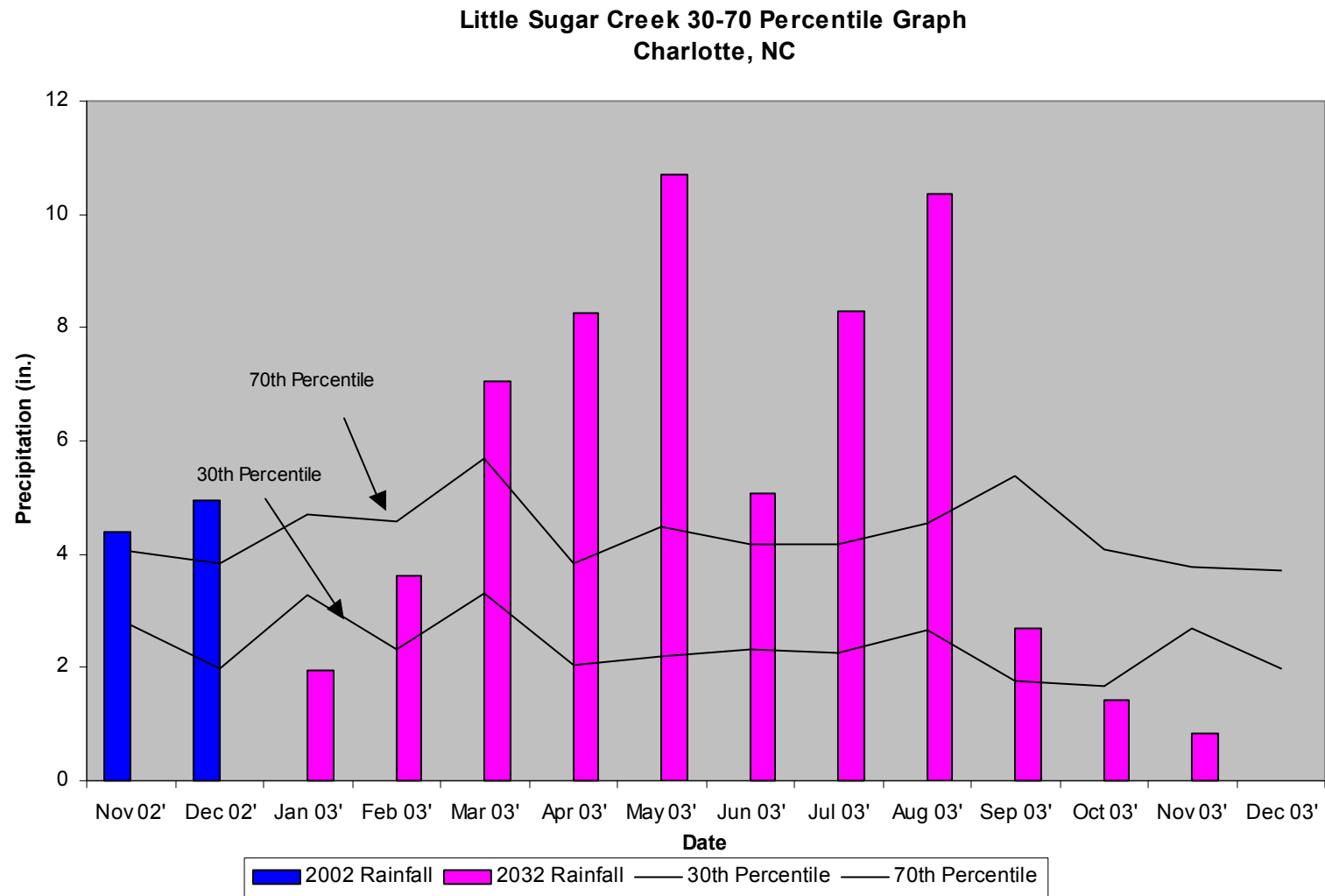
2.4 CONCLUSIONS

During the 2003-monitoring year, six of the nine gauges met the jurisdictional hydrology (saturation for 12.5% of the growing season). Two of the nine gauges that did not meet success experienced malfunctions, early in the growing season. The surface water gauges indicated persistent surface water in the channels throughout the growing season.

The emergency spillway modifications improved the site, hydraulically in the 2003-monitoring year. During an average to above average rainfall year, eight of the nine-groundwater gauges improved from the 2002-monitoring year (below average rainfall year).

NCDOT will continue to monitor the Little Sugar Creek Mitigation Site for hydrology.

Figure 4. 30-70 Percentile Graph



3.0 VEGETATION: LITTLE SUGAR CREEK MITIGATION SITE (YEAR 7 MONITORING)

3.1 SUCCESS CRITERIA

Success criteria state that there must be a minimum mean density of 320 characteristic tree species/acre surviving for at least three years in the bottomland forest area of the site. Characteristic tree species are those species planted along with natural recruitment of sweetgum, red maple, and loblolly pine. Loblolly pine cannot comprise more than 10% of the 320 trees per acre. No quantitative sampling requirements were developed for the herbaceous and shrub assemblages as part of the vegetation success criteria per the August 1995 mitigation plan.

3.2 DESCRIPTION OF SPECIES

The following shrub species were re-planted in the Wetland Shrub Restoration Area:

Cornus amomum, Silky Dogwood
Leucothoe axillaris, Dog Hobble
Rhododendron arborescens, Smooth Azalea
Sambucus canadensis, Elderberry
Viburnum nudum, Possum Haw
Aesculus sylvatica, Painted Buckeye
Lindera benzoin, Spicebush

The following herbaceous species were planted in the Channel Areas:

Juncus effusus, Soft Rush
Scirpus validus, Bulrush

The following tree species were planted in the Wetland Restoration Area:

Quercus michauxii, Swamp Chestnut Oak
Quercus falcata var. *pagodaefolia*, Cherrybark Oak
Quercus phellos, Willow Oak
Fraxinus pennsylvanica, Green Ash
Betula nigra, River Birch
Quercus lyrata, Overcup Oak
Quercus nigra, Water Oak

3.3 RESULTS OF VEGETATION MONITORING

Table 3. Vegetation Monitoring Statistics

Plot # (Type)	Silky Dogwood	Dog Hobble	Painted Buckeye	Green Ash	Water Oak	Cherrybark Oak	Overcup Oak	Swp Chestnut Oak	River Birch	Willow Oak	Total (7 year)	Total (at planting)	Density (Trees/Acre)
1 (Shrub)	14										14	30	317
2 (BLH)				13				2	2	3	20	30	453
3 (BLH)				10		1		1	1	3	16	30	363
AVERAGE TREE (BLH) DENSITY													408

Site Notes: Other species noted: *Juncus* sp., Queen-Anne's-lace, various grasses, foxtail, switchgrass, fennel, sycamore, locust, smartweed, volunteer green ash and gum, milkweed, *Aster* sp., wooly panicum, ragweed, woolgrass, and cottonwood. Elderberry noted in plot 1. Silky dogwood was noted in plots 2 and 3. Ditches were full of *Juncus* sp. Beaver activity was noted in plots 2 and 3.

3.4 CONCLUSIONS

Approximately 9.8 acres of this site were planted in bottomland hardwoods in March 1997. There were two vegetation monitoring plots established in the bottomland hardwood area, Plots #2 and #3. The 2003 vegetation monitoring revealed an average density of 408 trees per acre, which is above the 320 trees/acre minimum requirement.

Approximately 3.2 acres of this site were planted with shrub species. The 2003 vegetation monitoring of Plot #1 revealed an average density of 317 stems per acre. The remaining 3.7 acres were planted with herbaceous plant material. From visual observation, this plant material has established in the bottom and on the side slopes of the channels on the site.

NCDOT proposes to discontinue vegetation monitoring at the Little Sugar Creek Mitigation Site.

4.0 OVERALL CONCLUSIONS/RECOMMENDATIONS

In August 2003, NCDOT provided a letter to the U.S. Department of the Army to address the hydrologic concerns of securing an additional 13.1 acres of wetlands to replace the Little Sugar Creek Mitigation Site (Appendix D). NCDOT is currently still in discussion regarding this issue.

In October 2003, The Catena Group, Inc. conducted a site visit to evaluate the Little Sugar Creek Mitigation Site. The investigation examined soil features to determine any correlation between the past and current conditions on the site. The report can be found in Appendix D. Mitigation Site Soil Analysis.

During the 2003-monitoring year, six of the nine gauges met the jurisdictional hydrology (saturation for 12.5% of the growing season). Two of the nine gauges that did not meet success experienced malfunctions, early in the growing season. The surface water gauges indicated persistent surface water in the channels throughout the growing season.

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NCDOT will continue to monitor the site for hydrology.

APPENDIX A

GAUGE DATA GRAPHS

APPENDIX B

SITE PHOTOS

PHOTO/PLOT LOCATIONS

Little Sugar Creek



Photo 1



Photo 2



Photo 3



Photo 4



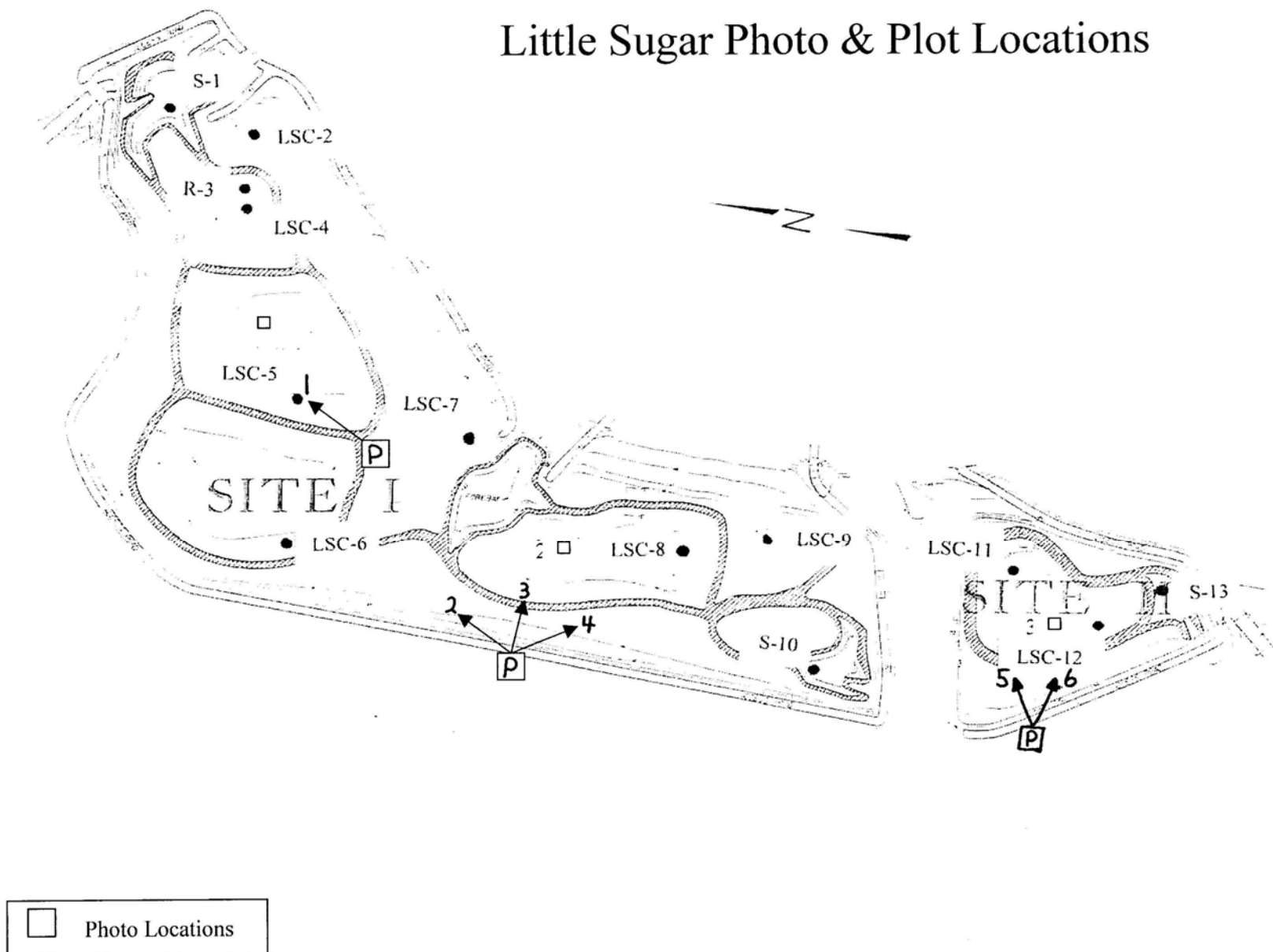
Photo 5



Photo 6

2003

Little Sugar Photo & Plot Locations



APPENDIX C

LETTER TO N.C. WETLAND RESTORATION PROGRAM,

OCTOBER 8, 2001



STATE OF NORTH CAROLINA
DEPARTMENT OF TRANSPORTATION

MICHAEL F. EASLEY
GOVERNOR

LYNDO TIPPETT
SECRETARY

October 8, 2001

Mr. Ronald E. Ferrell, Program Manager
North Carolina Wetland Restoration Program
NCDENR-DWQ
P.O. Box 29535
Raleigh, NC 27626-0535

Dear Sir:

Subject: REQUEST FOR ACCEPTANCE OF WETLAND MITIGATION for a
completed section of the Charlotte Outer, TIP R-211 DA

At the request of the US Army Corps of Engineers, the North Carolina Department of Transportation (NCDOT) would like to secure outstanding wetland mitigation credits for the above project with the North Carolina Wetlands Restoration Program. The cause for this request is that the one of the sites (Little Sugar Creek) originally secured by NCDOT as mitigation for R-211 DA is not sufficiently meeting hydrologic criteria. The specifics of the request are below.

- Mecklenburg County, Piedmont Province
- Catawba River Basin, Cataloguing Unit: 03050103
- 13.1 acres of restored wetland mitigation is required
- wetland type is non-riparian, bottomland forest

For 13.1 acres at a cost of \$12,000 per acre, NCDOT is proposing to provide payment in the amount of \$157,200 to offset wetland impacts. If you are willing to accept responsibility for compensatory mitigation for this project, please send a letter of confirmation to Mary Frazer at NCDOT, Project Development and Environmental Analysis Branch. If you have any questions or need additional information please call Mary Frazer at (919) 733-1200.

Sincerely,

William D. Gilmore, P.E., Manager
Project Development & Environmental Analysis Branch

cc: Mr. Steve Lund, USACE, Asheville Field Office
Ms. Cynthia Van Der Wiele, NCDENR, Division of Water Quality
Mr. David Franklin, Corps of Engineers, Wilmington Field Office
Mr. N. L. Graf, P.E., FHWA
Mr. John Dorney, NCDENR, Division of Water Quality
Mr. Benton G. Payne, P.E., Division 10 Engineer

MAILING ADDRESS:
NC DEPARTMENT OF TRANSPORTATION
PROJECT DEVELOPMENT AND ENVIRONMENTAL ANALYSIS
1548 MAIL SERVICE CENTER
RALEIGH NC 27699-1548

TELEPHONE: 919-733-3141
FAX: 919-733-9794
WEBSITE: WWW.DOH.DOT.STATE.NC.US

LOCATION:
TRANSPORTATION BUILDING
1 SOUTH WILMINGTON STREET
RALEIGH NC

APPENDIX D

LETTER TO U.S DEPARTMENT OF THE ARMY,

AUGUST 29, 2003



STATE OF NC
DEPARTMENT OF TRANSPORTATION

MICHAEL F. EASLEY
GOVERNOR

LYNDO TIPPETT
SECRETARY

August 29, 2003

Colonel Charles R. Alexander, Jr.
U.S. Department of the Army
Wilmington District, Corps of Engineers
P.O. Box 1890
Wilmington, North Carolina 28402-1890

Subject: Mecklenburg County, Little Sugar Creek Mitigation Site, TIP No. R-211
DA/DB/DD, USACE Action Id 199200023

Dear Colonel Alexander:

As you are aware, the North Carolina Department of Transportation (NCDOT) has received your letter dated May 19, 2003 regarding the hydrologic failure of the Little Sugar Creek Mitigation Site in Mecklenburg County. In this letter you suggested the NCDOT move expeditiously to secure an additional 13.1 acres of wetlands to replace the Little Sugar Creek Site, possibly securing mitigation in Lower Catawba, Upper Catawba, South Fork Catawba and Rocky River (Yadkin River Basin). The purpose of this letter is to inform the U.S. Army Corps of Engineers (USACE) of the NCDOT's actions since the May 2003 letter and to provide the USACE with options, including deadlines, to address the hydrologic failure at Little Sugar Creek Mitigation Site and other potential mitigation failures in the vicinity of Charlotte, North Carolina.

The NCDOT developed a broad strategy of how to address the concerns of securing an additional 13.1 acres of wetlands to replace the Little Sugar Creek Site. The strategy included working with N.C. Wetlands Restoration Program (NCWRP) to identify sites within Hydrologic Unit (HU) 03050103, to assess on-going mitigation site and bank development and to review NCDOT files for wetland mitigation sites in HU 03040105.

Mitigation Search in HU 03050103 (Lower Catawba River Basin)

The NCWRP provided the NCDOT with sixteen potential mitigation sites to review in the Union County area of HU 03050103. The sites were selected through Geographic Information System (GIS) review using 1991 digital aerial photography and deemed to have good mitigation potential. The strategy was for NCDOT to contact these

landowners via mail to gauge their interest in participating in the mitigation program. A field visit would then be arranged to verify mitigation potential on their property.

Of the sixteen sites provided to the NCDOT, eight sites were removed from consideration when digital aerial photography were reviewed as the sites had been developed and/or altered such that mitigation was not feasible. The NCDOT still contacted these landowners.

All property owners were contacted via mail, and the NCDOT received only two responses. The NCDOT has visited these two sites, and a summary of each reviewed site follows.

- Stewart Branch - South Fork Cane Creek. The landowner owns one side of waterway and existing buffer is over 200 feet in width. There were no wetlands found on the tract, and no wetland mitigation potential exists. The site should only be considered for preservation of approximately 2500 linear feet of one side.
- Tributary to Walker Branch. The NCDOT contacted multiple landowners along this reach of stream. The only interested landowner was Christ the King Lutheran Church. The site visit revealed that the site is limited because they only own one side of the identified waterway for approximately 500 linear feet. However, during the field visit, an additional waterway was found within the property. This area does have restoration potential although limited to stream mitigation. The initial discussion with the minister indicates that the church may have some interest in participating in the mitigation program for this waterway. The church currently has plans to develop much of the land it owns which may reduce ability to effectively restore the waterway. The NCDOT plans to meet with the minister of the church again in early September to review this property to further discuss a potential stream mitigation project.

The two sites visited by the NCDOT did not provide any wetland mitigation potential. The NCDOT has conducted numerous searches to identify wetland mitigation in rapidly developing areas such as in the Charlotte area, and the searches have yielded little to no wetland restoration.

Mitigation Review of HU 03040105 (Rocky River sub-basin, Yadkin River Basin)

The NCDOT has conducted a search for wetland mitigation in the Rocky River sub-basin within the Yadkin River Basin (HU 03040105). The NCDOT is working two approaches to generate replacement mitigation for Little Sugar in this HU.

The NCDOT identified several stream restoration sites during this search, but very little to no wetland restoration. One site, the Suther Estate Tract, offers much mitigation and environmental significance, including wetland preservation (bottomland hardwood) and limited restoration opportunities, stream mitigation, piedmont prairie and viable mussel fauna.

Mr. Steve Lund of the USACE Asheville Regulatory Field office visited the site with other resource agencies during Fall 2002. The agencies had much interest in the site because the site has many Natural Heritage elements. The NCDOT estimates, based on limited field review, wetland preservation (50 acres) exists on the tract as well as limited opportunities (2 acres) for wetland restoration.

The NCDOT has spent the past year working to secure an option on the tract for mitigation due to the tract being designated under a farmland easement. The NCDOT is currently working to develop a stream/wetland mitigation plan for the tract, including a wetland delineation to determine the wetland preservation available. The NCDOT believes it can have a mitigation plan to submit to the resource agencies in December 2003. The wetland mitigation generated by this project could be one option to replace the mitigation needed at Little Sugar Creek.

The NCDOT is currently reviewing its mitigation search information to determine whether there was any wetland enhancement or preservation initially identified in Rocky River sub-basin of Yadkin River Basin. Of particular interest to date is a bottomland hardwood wetland complex along Clarke Creek in Cabarrus County. The NCDOT has met with Mr. Dennis Testerman of Cabarrus County Soil and Water Conservation District about this wetland area. Based on a limited field review, the wetland complex is estimated to be 30-50 acres in size. There are eight property owners along this wetland complex with one landowner having about 20 acres of wetlands. The NCDOT will be initiating conversations in September 2003 with the landowner owning approximately 20 acres of potential wetland preservation to determine landowner interest in protecting this wetland system (via a conservation easement or fee simple acquisition).

Key Branch Mitigation Site, Anson County (HU 03040104, Yadkin River Basin)

The NCDOT has a signed conservation easement for this mitigation site located in Anson County. The site lies within the Yadkin River Basin (HU 03040104). The NCDOT has completed a final mitigation plan and 100% design plans. Construction will commence during Fall 2003 with planting to follow during Spring 2004.

The site consists of 74 acres of restoration (piedmont bottomland hardwood) and 3.6 acres of preservation (piedmont swamp forest). The NCDOT is working to purchase additional preservation adjacent to the site. To date, there are 18 acres of restoration and 3.6 acres of preservation remaining at the site.

Pott Creek Mitigation Bank, Lincoln County (HU 03050102, Catawba River Basin)

The NCDOT has purchased all available credits, when available for use, from the Potts Creek Mitigation Bank in Lincoln County. This site lies within HU 03050102 of the South Fork Catawba River sub-basin.

The wetland mitigation project was constructed during Winter 2002 and planted during Spring 2002. Minor adjustments were made to a portion of bank during Winter 2003.

It is NCDOT's understanding that the Mitigation Banking Instrument (MBI) for the bank has not been signed. The bank will have 16.34 credits (5.45 acres of restoration, 31.32 acres of creation, 0.76 acres of enhancement and 0.36 acres of preservation) of wetland mitigation available upon completion of all monitoring for the bank.

Future of Little Sugar Creek

As it pertains to the existing Little Sugar Creek Mitigation Site, the NCDOT has made adjustments to Little Sugar over the past several years to correct hydrology loss due to the water control devices at the site. The NCDOT made modifications to the site prior to Spring 2002. However, during that year, as well as in 2001, the Charlotte area experienced a severe drought thereby inhibiting the NCDOT from determining the effectiveness of the modification work. The NCDOT believes these alterations to the site have improved its ability to meet the hydrological criterion for the site.

The NCDOT has continued hydrological monitoring of Little Sugar Creek during the growing season for 2003. Based on a review of the groundwater and surface water gauges at the site, most all of the gauges have met the 12.5% hydrological criterion. The NCDOT acknowledges plentiful rainfall in the Charlotte area during the 2003 growing season. The NCDOT has requested rainfall totals to determine if this year's rainfall lies within the 30-70 percentile for historical rainfall totals for the area. The NCDOT will submit hydrological data gathered for the year in a report (gauge and rainfall data) to the USACE by September 26, 2003.

The NCDOT agrees an alternate plan of replacement mitigation at Little Sugar Creek is needed given the past performance of meeting the hydrologic criterion for the mitigation site. In spite of the hydrological shortfalls that have occurred, Little Sugar Creek provides many wetland functions and benefits. The NCDOT, therefore, respectfully requests that partial mitigation credit be provided for the site.

The NCDOT proposes to delineate the site as it exists now to determine how much of the area is a wetland. The NCDOT will delineate the site by September 26, 2003 and be available to review the site with the USACE in October 2003 and to further discuss the NCDOT's request for partial credit for the site.

In summary, the NCDOT believes that we have made a strong, good faith effort to identify mitigation opportunities in the Little Sugar Creek area. Based on those good faith efforts, we believe that several viable options to replace mitigation at Little Sugar Creek include the following:

- Potts Creek Mitigation Bank. Upon signing the MBI, the NCDOT would apply mitigation credits available at the bank toward the mitigation needs caused by the hydrological failure at Little Sugar Creek;
- Key Branch. The NCDOT can debit immediately, at the most, 13.1 acres from the site for which NCDOT has a conservation easement, final mitigation plan, 100% design plans and will commence construction during Fall 2003;
- Suther Estate Tract. A mitigation plan can be presented to the agencies in December 2003, including a delineation of a bottomland hardwood forest for wetland preservation credit (estimated to be 50 acres) and minimal wetland restoration (estimated to be 2 acres);
- Clarke Creek. The NCDOT has commenced discussions with property owners about protecting the bottomland hardwood wetland complex; and,
- Little Sugar Creek. The NCDOT will provide gauge and rainfall data to the USACE by September 26, 2003. The NCDOT will continue hydrologic monitoring of the site as the NCDOT believes its modifications have been effective based on a review of data from surface water and groundwater gauges at the site. The NCDOT will delineate Little Sugar Creek by September 26, 2003 and can review the site with the USACE in October 2003.

Of the described options, the NCDOT believes the preferred option to address the immediate replacement of mitigation at Little Sugar Creek is debiting credits from the Potts Creek Mitigation Bank. If there are not sufficient credits available to cover the shortfall, the remaining needed mitigation may be used from Key Branch. The third option would be to use mitigation from Key Branch to meet the shortfall at Little Sugar Creek. The fourth option would be to use the mitigation that will be available at Suther Estate Tract in December 2003. The remaining efforts of NCDOT with Clarke Creek and other enhancement/preservation lands in HU 03050103 (and the Suther Estate Tract if the tract is not selected as replacement mitigation for Little Sugar Creek) would be used for any potential future mitigation failures at Long Creek and Mallard Creek.

We appreciate your consideration of this important matter. If you have any questions about NCDOT's mitigation effort for this project, please contact Mr. Phillip Todd of my staff at (919) 715-1467.

Sincerely,

Gregory J. Thorpe, Ph.D., Environmental Management Director
Project Development and Environmental Analysis Branch

cc: Mr. Roger Sheats, NCDOT Deputy Secretary
Mr. Ken Jolly, Chief, USACE Wilmington District Regulatory Division
Mr. Steve Lund, USACE Coordinator for NCDOT

APPENDIX E

MITIGATION SITE SOIL ANALYSIS

INTRODUCTION

The Little Sugar Creek Mitigation Site and Mallard Creek Mitigation Site are the property of the North Carolina Department of Transportation (NCDOT). Both sites are located in Mecklenburg County, NC and have been constructed to provide wetland mitigation for NCDOT road projects in the county.

Little Sugar Creek was constructed in the winter of 1996-97. The site was modified in 2002 in an effort to increase its hydrologic regime. Mallard Creek was constructed in 1994 and underwent remediation in 1997. It is divided into two sites. Site 1 is located south of Mallard Creek Church Road. Site 2 is located on the opposite side of Mallard Creek Church Road.

The hydrologic success as stated in the both Mitigation Plans reads:

“...that the area must be inundated or saturated (within 12” of the surface) by surface or groundwater for at least a consecutive day percentage of 12.5% of the growing season. Areas inundated or saturated for less than 5% of the growing season are always classified as non-wetlands. Areas inundated or saturated between 5% - 12.5% of the growing season can be classified as wetlands depending on upon factors such as the presence of the wetland vegetation and hydric soils.”

Aside from Mallard Creek Site 1, which has met the hydrologic success criteria for five consecutive years, neither Little Sugar Creek nor Mallard Creek Site 2 have yet to fully meet the hydrologic success criteria, despite efforts to modify both sites. As a result, the US Army Corps of Engineers has requested that NCDOT determine the area of each site that has failed to meet the hydrologic success criteria. Furthermore, they have requested that NCDOT immediately provide alternative mitigation for the failed section of the Little Sugar Creek Site through in-lieu payments to the North Carolina Wetlands Restoration Program (WRP).

However prior to abandoning the failed sections and relinquishing the associated mitigation credits, NCDOT has chosen to do additional research on the sites. It is anticipated that this research will determine if the sites exhibit any characteristics that suggest those failed sections could potentially meet the success hydrologic success criteria. To this end, NCDOT has requested The Catena Group, Inc. to investigate both sites, concentrating on the soils perspective.

Purpose

The purpose of this report is to evaluate the Little Sugar Creek Mitigation Site and the Mallard Creek Mitigation Site. The investigation will examine the physical and morphological features of the soils, as well as physical features of each site, in order to determine any correlation between the past and current conditions. Based on these findings, an assessment of the future viability of each site will be performed.

Wetland Creation

Wetland creation has been defined as the conversion of a persistent upland or shallow-water area into a wetland by human activity (Mitsch and Gosselink, 2000). Both of the subject sites can be considered creation sites in that they involved removal and grading of earth to create areas of sustained hydrology at or near the soil surface.

The hydrologic success criteria for both sites require saturation within 12-inches of the soil surface for at least 12.5% of the growing season for five consecutive years. In Mecklenburg County, the growing season begins March 22 and extends through November 11 (235 days), which equates to 29 consecutive days. If alterations are made to the site, then the five-year monitoring periods must begin anew. While both sites have been altered, they have been continually monitored since their creation.

Ecological Development of Created Wetlands

Understanding the complex nature of wetlands well enough to successfully create or restore their function requires substantial training in plants, soils, wildlife, hydrology, water quality, and engineering. According to Mitsch and Wilson (1996), a major flaw in the measurement of wetland mitigation success is the limited amount of time that regulators and the land development process allow for newly created wetlands to develop before passing judgment. After five years of monitoring a mitigation wetland, only a general idea of the wetlands ecological trajectory can be known. The further the conditions are in the beginning from the targeted natural steady state, the longer it will take for that system to reach or approach steady state. For example, the replacement time frame for freshwater marshes is typically 15 or 20 years, far beyond the current requirement of a 5 year establishment. Other wetland types such as forested wetlands, coastal wetlands, or peatlands may take even longer (50 years to a lifetime) for wetland functions to be restored (Mitsch and Gosselink, 2000).

Wetland soils

Wetland soils are both the medium in which many of the wetland chemical transformations take place and are the primary storage of available nutrients for most wetland plants. They are often described as hydric soils, defined by the U.S.

Department of Agriculture's Natural Resources Conservation Service (NRCS) as "soils that formed under conditions of saturation, flooding or ponding long enough during the growing season to develop anaerobic conditions in the upper part".

Wetland soils are of two types, mineral or organic. Nearly all soils have some organic material, but when a soil has less than 20 to 35 percent organic matter (on a dry weight basis), it is considered a mineral soil, as are the soils in both mitigation sites.

Wetland Soils Formation

When soils are inundated with water for an extended period, anaerobic conditions usually result. The rate at which oxygen can diffuse through the soil is drastically reduced, about 10,000 times slower than oxygen diffusion through a drained soil. This low diffusion rate leads relatively quickly to anaerobic, or reduced conditions, with the time required for oxygen depletion on the order of several hours to a few days after inundation begins (Mitsch and Gosselink, 2000).

When a mineral soil is exposed to anaerobic conditions, it develops certain characteristics that allow for its identification. These characteristics are collectively called redoximorphic features, defined as features formed by the reduction, translocation, and/or oxidation of iron (Fe) and manganese (Mn) oxides (Mitsch and Gosselink, 2000). Soil inundation results in the development of these features, such as a reduced matrix and redox concentrations (i.e., zones of apparent accumulation of Fe-Mn oxides).

The development of redoximorphic features in mineral soils is mediated by microbiological processes. The rate at which they are formed depends on four conditions, all of which must be present:

1. Saturated conditions
2. Sustained anaerobic conditions
3. Sufficient soil temperature (5° C is often considered "biological zero," below which much biological activity ceases or slows considerably)
4. Presence of organic matter to serve as a substrate for microbial activity (Mitsch and Gosselink, 2000)

If microorganisms are not present, redoximorphic features will not form. If organic carbon levels are too low, there may be insufficient microbial respiration to deplete the diffused oxygen levels, even when the soil is saturated (Richardson and Vepraskas, 2001). Moving water tends to carry oxygen into the soil and retards the onset of Fe reduction (Richardson and Vepraskas, 2001). The time required for Fe reduction to occur after initiation of saturation or inundation depends on soil conditions. Studies indicate that Fe reduction can take as little as one day to as long as four or more weeks (Richardson and Vepraskas, 2001). There is a lag between the onset of saturation and

the onset of Fe reduction, and the length of the lag period depends on both soil temperature and organic matter percentage (Richardson and Vepraskas, 2001).

The oxidation of Fe can occur quickly. Laboratory experiments have shown that after eight hours approximately 78% of the ferrous iron had oxidized at 20° C while approximately 60% of the iron had oxidized in three hours (Richardson and Vepraskas, 2001).

A reduced matrix requires that the ferric iron cations in oxides or hydroxides to be reduced. Iron depletions require the same conditions as a reduced matrix and that the solubilized ferrous iron has moved to another portion of the soil. The formation of redox concentrations requires the solubilized iron from one area of the soil to become oxidized in another areas of the soil, forming Fe masses, pore linings, or nodules. The time required to form a reduced matrix has not been determined (Richardson and Vepraskas, 2001).

Oxidized rhizospheres are another characteristic of mineral wetland soils. They result from the capacity of many hydrophytes to transport oxygen through above-ground stems and leaves to below-ground roots. Mineral soils that are seasonally flooded, particularly by alternate wetting and drying, develop spots of highly oxidized materials called redox (redoximorphic) concentrations. Redox concentrations are orange/reddish-brown due to iron, or dark reddish-brown/black spots due to manganese. Redox concentrations are relatively insoluble, enabling them to remain in soil long after it has been drained (Mitsch and Gosselink, 2000).

Another extremely important factor in the development of soils is the development of vegetation. Bare exposed soil has a much slower rate of infiltration and a higher rate of runoff than soil with established vegetation. As vegetation becomes established it performs the following functions:

- reduces the amount of soil erosion
- retains water on the site for longer periods, thus increasing the time for infiltration
- forms an insulating layer that retains moisture in the soil
- provides food and cover thereby promoting the growth of micro and macro organisms.

In addition to these functions, as the roots develop in the soil and development of soil structure ensues, the following benefits are realized:

- increased porosity and water infiltration
- subsurface accumulation of organic matter and improved water holding capacity
- creation of pathways for micro and macro organisms and nutrients to enter the soil.

While these functions are listed separately, they are interdependent and self promoting. The development of soils and plants will continually compliment one another even after the wetland has reached steady state.

Wetland Soils – Current Versus Relict Redoximorphic Features

Redox concentrations indicate where oxidation has occurred in the past. By themselves, these features give no indication of how long a soil has been saturated and reduced. A relict reduction feature is one that has formed in the past and persists in the soil where it can no longer form today, thus giving the impression a soil is wetter than it really is. Redoximorphic features that are either redox depletions or redox concentrations are the most likely morphological features to be relict. The reduced matrix must be kept reduced and can never be relict. Any time a morphological feature, which had to form along a macropore, is found in the matrix or away from a pore, it can be assumed that it did not form recently and should be considered relict. When redox concentrations form, they have diffuse boundaries, sometimes seen as a halo or ring, around the iron concentration. Diffuse boundaries are assumed to indicate that the feature is forming or has formed in the recent past and is reflecting current hydrologic conditions. When redox concentrations begin to dissolve, or are mixed into the matrix, they acquire sharp boundaries within the matrix, and are thus considered features that are no longer forming, or relict (Richardson and Vepraskas, 2001).

Occasionally morphological features do not form in soils that are seasonally saturated and reduced, especially floodplain soils. The reasons for this are not completely understood, but probably relate to the fact that little Fe reduction occurs, possible due to one or more of the following: low amounts of organic carbon at the time of saturation, a high pH, high levels of manganese oxides in the soil, or large amounts of dissolved oxygen in the water (Richardson and Vepraskas, 2001).

LITTLE SUGAR CREEK MITIGATION SITE

The Little Sugar Creek Mitigation Site occurs within the Charlotte Belt which is composed of igneous and metamorphic rocks covered by regolith consisting of weathered in place residuum and soil. Field activities revealed that bedrock on site is overlain by 10 to 15 feet of clayey soil at the surface with saprolite underneath. The landscape is characterized by a low floodplain with clay ridges, small depressions, and relict stream channels (ESI, 1995).

The soils were mapped by the NRCS as being dominated by the Monacan mapping unit. These are nearly level, somewhat poorly drained soils that have a predominantly loamy subsoil and were formed in fluvial sediment on floodplains (Soil Conservation

Service, 1980). The construction plan called for the removal and stockpiling of the top six inches of the soil for replacement once the grading was completed.

Personnel from The Catena Group, Inc. visited the site on October 20, 2003. A hand auger was used to perform detailed soil boring analyses adjacent to four groundwater monitoring gauges, LSC 4, 6, 8, and 11. A detailed description of each is included in Attachment A. The first profile, Soil Profile 1, was performed at LSC 6, which met the hydrologic success criteria for greater than 12.5% of the growing season in 2002.

The soil at LSC 6 showed clear evidence of recent development of redoximorphic features near the soil surface. There were both concentrations and depletions in the top 13 inches, which also corresponded with the effective rooting depth. In the horizons below the root zone, only areas of concentrations were found, including manganese masses, until the C3 horizon, at a depth of 51+ inches, where depletions of chroma 2 began.

The soil profile at LSC 6 is fluvial in origin with little development. However, the fact that areas of depletions are present in the surface horizons (in correlation with the 13 inch effective rooting depth), yet not below this level, indicates that this soil is only just beginning to develop. It is anticipated that as the vegetation continues to establish itself, the soil will continue its development. This will result in the development of improved infiltration and wetter conditions for the reasons previously detailed in this report.

Soil Profile 2 was taken adjacent to LSC-4, which thus far has had a hydrologic regime of less than 5% of the growing season. This soil has developed from residuum, as opposed to fluvial sediments. In this soil, areas of depletions and concentrations are evident throughout the soil profile in contrast and abundance typical of more well developed soils.

The surface horizon of Soil Profile 2 is 10 inches thick and has areas of concentrations and depletions. The subsurface horizon immediately beneath the surface horizon exhibits the same colors and features except for the lack of depletions. This is the same trend noted in Soil Profile 1. However, in Soil Profile 2 the depletions were few and faint while those in Soil Profile 1 were common and distinct, which corresponds well with the slightly reduced hydrologic regime registered near LSC-4. Nevertheless, the important item of note is that this area also appears to be developing hydric soil, albeit at a slower pace than LSC-6, and assuming conditions remain constant, the area is expected to become wetter over time.

Soil Profile 3 was placed near LSC-8, which in 2002 met the wetland hydrology criteria for 12.3% of the growing season. This profile exhibits the same features and characteristics as those in Soil Profile 1, except that the development of the surface horizon(s) is even more pronounced than the subsurface horizons.

Soil Profile 4 was taken near LSC-11, which in 2002 met the wetland hydrology for 6.8% of the growing season. The spreading of topsoil after grading was completed is clearly evident at this site. The topsoil layer is 8 inches and is immediately underlain by parent material. However, once again, areas of concentration and depletions are evident in the topsoil. While this soil will also continue to develop, it is anticipated that it will take considerably longer since the underlying parent material is a medium that is more difficult to weather and develop than the soil found in other areas of the site.

MALLARD CREEK MITIGATION SITE

Less design information is available on the Mallard Creek Mitigation Site, but the information obtained suggests that the site was graded down to where the average ground water table exists, as much as 24-inches in some locations. The well data over two years in the late 1990's indicates that Site 1 met the wetland hydrology requirements while Site 2 was failing in some areas and successful in others.

Personnel from The Catena Group, Inc. visited the site on October 20, 2003. A hand auger was used to perform detailed soil boring analyses adjacent to three monitoring gauges, MW- 2, 5, and 8. The detailed description of each is included in Attachment B.

The first profile, Soil Profile 5, was taken at MW-2 in Site 1. This profile exhibited more hydric features than any of the other profiles. As might be expected, this area has proven to be the wettest area in either mitigation site, based on groundwater gauge data. This soil is developing from alluvial sediments and actually revealed a buried hydric soil horizon at 41 inches. Also interesting to note is the lushness and density of the vegetation throughout this site when compared with the vegetation from the others.

Soil Profiles 6 and 7 were performed in Site 2 at MW-8 and MW-5, respectively. The most obvious difference between profile 5 and profiles 6 and 7 is that these soils are developing from residuum. This soil was graded down to the target elevation without any topsoil placed back over the top. Newly formed redoximorphic features are much more difficult to discern in these profiles since they are developing in a soil medium that already contained both relict and recently developed redoximorphic features. Nevertheless, there appears to be some evidence that these soils are beginning to develop such as small manganese concretions and oxidized rhizospheres.

DISCUSSION

The soils at both the Little Sugar Creek and Mallard Creek Mitigation Sites exhibit signs of recent soil development that is occurring at least partially under hydric conditions. Sites that have been consistently wetter exhibit more hydric features that are easier to discern than those which have been drier. This does NOT necessarily indicate that these wetter areas are simply exposed to longer periods of inundation. There are likely

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a multitude of other factors, such as better soil structure or more organic matter in the soil, that are causing differences in hydroperiod.

Stolt et al. (2000) note other factors that often impact soils in created wetlands:

1. As the top soil was removed and reapplied once grading was completed, the soil profiles were altered in a way that may be hindering the steady pace of hydric soil development.
2. Soils of constructed wetlands are often higher in temperature due to the lack of vegetation and organic matter, and possibly drier conditions. This leads to faster microbial activity and less accumulation of organic matter.
3. The water table rises and falls more quickly in constructed wetlands than in natural wetlands. This may be due to the lack of organic matter and soil structure. Soils high in organic matter have higher water holding capacities, which, in turn, improve reducing conditions.
4. In areas that are graded down, the exposed soil layer has not had the same exposure to the level of organic acids and intensity of weathering as subsoil in a natural wetland.

The effect of vegetation cannot be understated. Plants add organic matter and increase structure (through root growth) so that more water can infiltrate and percolate down through the soil profile. As plants die and detritus is incorporated into the soil profile by microorganisms and other fauna, the organic matter content increases, increasing water holding capacity and structure. This process takes time. Initially, more surface water will run off then infiltrate into the soil. Once plants are established and the amount of organic matter starts to increase, more water will infiltrate into the soil, the water holding capacity will continue to increase, and the soils will start to display more hydric indicators.

The soil profiles show that recently developed redoximorphic features are present. While there is no guarantee that these soils will eventually become hydric, they need more time to develop before any conclusions can be reached. All wetlands take time to form, especially constructed wetlands. They should not be expected to form quickly. If the desired hydrology takes longer than expected to become established, so will hydric soils and hydrophytic plants. This does not necessarily mean, however, that these mitigation sites are not achieving some of the desired functions that they were intended to perform. They both capture storm water runoff from nearby roadways, and the Little Sugar Creek site also retains water from the nearby shopping mall/hospital complex. These functions should not be overlooked while these sites continue to develop.

ATTACHMENT A
Little Sugar Creek Soil Profiles

Soil Profile 1 (LSC-6)

- A 0-7 inches; dark yellowish brown (10YR 3/4) silt loam with common distinct strong brown (7.5YR 5/8) concentrations and common distinct brown (10YR 4/3) concentrations; friable, medium, subangular blocky structure breaking to coarse granular structure.
- Bw1 7-13 inches; strong brown (7.5YR 5/6) sandy loam with few prominent dark red (2.5YR 3/6) concentrations and common distinct light yellowish brown (10YR 6/4) depletions; friable, medium subangular blocky structure. Effective rooting depth 13 inches.
- Bw2 13-24 inches; strong brown (7.5YR 5/6) sandy loam with few distinct yellowish red (5YR 5/8) concentrations; very friable, subangular blocky structure. Hard manganese concretions present.
- C1 24-38 inches; yellowish brown (10YR 5/6) sandy loam; massive structure. 20% manganese concretions.
- C2 38-51 inches; yellowish brown (10YR 5/6) sandy loam, massive structure. 25% hard manganese concretions and soft manganese masses.
- C3 51-60+ inches; light yellowish brown (10YR 6/4) sandy loam with few distinct light brownish gray (10YR 6/2) depletions; massive structure.

Soil Profile 2 (LSC-4)

- A1 0-10 inches; dark yellowish brown (10YR 4/6) fine sandy loam with common distinct strong brown (7.5YR 4/6) concentrations and few faint dark yellowish brown (10YR 4/4) depletions; friable, granular structure.
- A2 10-16 inches; dark yellowish brown (10YR 4/6) fine sandy loam with common faint strong brown (7.5YR 4/6) concentrations; very friable, granular structure. Effective rooting depth 15 inches.
- EB 16-28 inches; strong brown (7.5YR 4/6) sandy loam with common distinct brown (10YR 4/3) depletions; very friable, coarse subangular blocky structure.
- Btg1 28-45 inches; brown (7.5YR 4/4) clay loam with common faint strong brown (7.5YR 4/6) concentrations and common distinct dark grayish brown (10YR 4/2) depletions; firm, subangular blocky structure.
- Btg2 45-60+ inches; brown (7.5YR 4/4) clay with common faint strong brown (7.5YR 4/6) concentrations and many distinct dark grayish brown (10YR 4/2)

depletions; firm, subangular blocky structure. Common soft manganese masses.

Soil Profile 3 (LSC-8)

- A 0-3 inches; dark yellowish brown (10YR 4/4) sandy loam with common distinct strong brown (7.5YR 4/6) concentrations and few faint brown (10YR 4/3) depletions; friable, subangular blocky breaking to granular structure.
- Bw 3-9 inches; dark yellowish brown (10YR 4/4) clay loam with few distinct strong brown (7.5YR 5/6) concentrations and common distinct dark grayish brown (10YR 4/2) depletions; friable, subangular blocky structure. Effective rooting depth 10 inches.
- BC 9-22 inches; dark yellowish brown (10YR 4/4) sandy loam, very friable, weak subangular blocky structure.
- C 22-60+ inches; dark yellowish brown (10YR 4/6) sandy loam; massive structure.

Soil Profile 4 (LSC-11)

- A 0-8 inches; yellowish brown (10YR 5/4) clay loam with few distinct strong brown (7.5YR 5/8) concentrations and common faint brown (10YR 5/3) depletions; friable, subangular blocky structure. Effective rooting depth 8 inches.
- 2C 8+ inches; parent material.

ATTACHMENT B
Mallard Creek Soil Profiles

Soil Profile 5 (MW-2)

- A 0-6 inches; dark yellowish brown (10YR 4/4) silt loam with common distinct grayish brown (10YR 5/2) depletions and few distinct strong brown (7.5YR 4/6) concentrations; friable, subangular blocky structure.
- Bw 6-16 inches; dark yellowish brown (10YR 4/4) clay loam with common distinct grayish brown (10YR 5/2) depletions, few distinct strong brown (7.5YR 4/6) concentrations, and few prominent red (2.5YR 4/6) concentrations; friable, subangular blocky structure. Effective rooting depth 12 inches.
- 2C 16-22 inches; dark yellowish brown (10YR 4/4) sandy clay loam with many distinct grayish brown (2.5Y 5/2) depletions and common distinct yellowish red (5YR 4/6) concentrations; friable, subangular blocky structure.
- 3Cg 22-30 inches; grayish brown (2.5Y 5/2) silt loam with common prominent yellowish red (5YR 4/6) concentrations; friable, subangular blocky structure.
- 4C 30-41 inches; dark yellowish brown (10YR 4/4) sandy clay with common distinct grayish brown (10YR 5/2) depletions; firm, subangular blocky structure.
- Ab 41-55 inches; gray (10YR 5/1) clay loam with common distinct strong brown (7.5YR 5/8) concentrations; firm, subangular blocky structure.
- Bgb 55-60+ inches; gray (10YR 5/1) sandy loam with few distinct yellowish brown (10YR 5/8) concentrations.

Soil Profile 2 (MW-8)

- AB 0-12 inches; strong brown (7.5YR 4/6) clay loam with many distinct brown (10YR 5/3) depletions; friable, coarse, subangular blocky structure. Common, small manganese concretions.
- Bt 12-26 inches; brown (10YR 5/3) clay loam with many distinct yellowish red (5YR 4/6) concentrations; friable, subangular blocky structure.
- Btg1 26-39 inches; gray (10YR 5/1) clay with many distinct dark yellowish brown (10YR 4/6) concentrations and common distinct yellowish brown (10YR 5/8) concentrations; friable, subangular blocky structure.
- Btg2 39-48 inches; gray (10YR 6/1) clay with many distinct brownish yellow (10YR 6/8) concentrations; very firm, subangular blocky structure.
- Btg3 48+ inches; bluish gray (5PB 6/1) clay with many prominent yellowish brown (10YR 5/8) concentrations; very firm, subangular blocky structure. Few manganese concretions present.

Soil Profile 3 (MW-5)

- AC 0-6 inches; brown (7.5YR 4/4) clay loam with many distinct strong brown (7.5YR 5/6) concentrations and common distinct brown (10YR 4/3) depletions; friable, subangular blocky structure.

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